Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

SD11
.U5936

IND/STA

United States
Department of
Agriculture

Forest Service
Southern Region

Forest Fertilization in the South

A Status Report

Forestry Report R8-FR2
September 1983

U. S. Department of Agriculture

Forest Service
Southern Region
1720 Peachtree Rd., N.W.
Atlanta, Georgia 30367

September 1983

Metric Conversions

1 foot	30.48 centimeters
1 acre	0.4047 hectare
1 pound	543.59 grams
1 ton	0.9072 metric ton
1 cord	3.6 cubic meters

U. S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY
RECEIVED

JUL 26 1984

EXCHANGE UNIT
ACQUISITIONS SECTION

245

FOREST FERTILIZATION IN THE SOUTH --

A Status Report

John R. Vann[1/] and George N. Brooks[2/]

Abstract--Forest fertilization interacting with other silvicultural activities such as selective thinning, vegetation control, prescribed burning, are opening new profit horizons for tree farmers. Research shows foliar analysis is more reliable than soil analysis in predicting the response of southern pines to phosphorus. The response of chemical fertilizers to specific sites depends upon soil type, source of fertilizer, rate of application, timing of application and to some extent, the method of application. Fertilization of young pine stands with nitrogen now appears to be effective in the Piedmont and Upper Coastal Plain, while the addition of phosphorus is most important in the Lower Coastal Plain. In the Gulf West Coastal Plain of the south, the time of rainfall differs from other locations, occurring at a less favorable time; thus fertilization is less critical than the moisture conditions of the soil, and weed competition, in controlling early stand establishment.

Introduction

Intensive forest management is important for meeting future timber production goals as population and other land use demands increase. Land owners are demanding more information on natural and artificial means of maintaining and improving soil productivity. A primary purpose of managing forest lands is to promote increased wood production in a cost-effective manner by applying the appropriate combination of silvicultural inputs.

Since the Pilgrims came to this country early in the seventeenth century, man has collected information on nutrient amendments to crops. However, it was not until the twentieth century that inorganic fertilizers have been an integral part of agricultural production. Fertilizer usage in forestry has lagged well behind that in agriculture. In the early 1930's, when Paul and Martz first started research in forest fertilization, serious interest in this field was rather low keyed. Perhaps the increase in demand for forest products during the past 20 years has caused the greatest changes in foresters' attitudes about forest fertilization. Research during this period has demonstrated that fertilization can increase wood production on many sites. However, if this new technology in forest fertilization is to help the nation meet increasing demands for wood, it must satisfy criteria for economic feasibility in commercial applications. These economic constraints require fertilization by prescription based on numerous factors such as site, stocking, stand age, cost of fertilization, and stumpage price. One can see why it is imperative for a land manager to have a useful guide for selecting appropriate fertilizer inputs which meet the objectives of increased wood production and cost-effectiveness.

[1/] Soil Science Specialist, Southern Region, USDA Forest Service

[2/] Program Development Forester, Southern Region, USDA Forest Service

STATUS OF FOREST FERTILIZATION IN THE SOUTH

In the 1960's, the interest in forest fertilization grew rapidly. This was triggered by new information on tree response to phosphorus (P) in the South and responses to nitrogen (N) in the Pacific Northwest. The findings stimulated formation of the Cooperative Research in Forest Fertilization (CRIFF) Program headquartered in Florida; and then the formation of the North Carolina State Forest Fertilization Cooperative (NCSFFC) and the Regional Nutritional Research Program (or RNRP) at the University of Washington. Their primary objective was to study the feasibility of increasing wood production through chemical amendments to the soil.

CRIFF's major research emphasis was initially on P fertilization of slash pines in the Atlantic Coastal Plain. NCSFFC emphasized N fertilization (approximately 99 percent) on loblolly pine, with less emphasis (<1 percent) on N and P fertilization of slash pine in the Piedmont and Upper Coastal Plain. The RNRP research concentrated on N fertilization of young to middle-aged stands of Douglas-fir on the west side of the Cascades.

The following generalizations on pine fertilization have emerged from various research projects:

1. Fertilizers primarily benefit the tree and not the site, with the possible exception of P fertilizers. Site improvement is considered to occur where the fertilizer incorporated into the soil improves the original available nutrient capital for a period exceeding the original rotation.

2. Fertilization, particularly when combined with weed control and/or site preparation techniques, accelerates early tree development, which leads to good stand establishment and shortens the time needed to produce the desired product or rotation age.

3. Young trees have greater nutrient demands from the soil than mature trees. Therefore, fertilization is often designed to overcome nutrient deficiencies early in the rotation. As the stand matures, fertilization may not be needed because nutrients are recycled through litter fall decomposition, which provides enough nutrients to sustain acceptable growth.

4. Fertilization is very site specific; dependent on nutrient reserves and availability. Fertilizer responses are influenced heavily by climatic conditions and other factors. For example, in the west Gulf Coastal Plain, fertilization response is influenced by rainfall pattern, soil physical and chemical conditions, and vegetative competition-often the dominant factors governing survival and growth (Shoulders and McKee).

5. Wood quality is not generally affected by fertilization, except that density may be lowered slightly on sites when exceptionally fast growth is obtained.

6. The effects of N applications may not last for more than 5 to 10 years, but the effect of P may last for the entire rotation.

Site Factors Influencing Fertilizer Use

A. Competition:

Haywood (1979) found that weed control is an important factor in establishing slash pine stands on gently rolling, somewhat poorly drained to moderately well drained sites in the West Gulf Coastal Plain (Figure 1). Fertilization plus herbicides produced dramatic early growth responses by slash pine, when compared with trees planted in bluestem grass (*Andropogon scoparius* Michx.). Without weed control, the grass captured the nutrients and tree growth was not accelerated. Soil moisture may also be a limiting factor; the grass competition for soil moisture negates the fertilizer treatment.

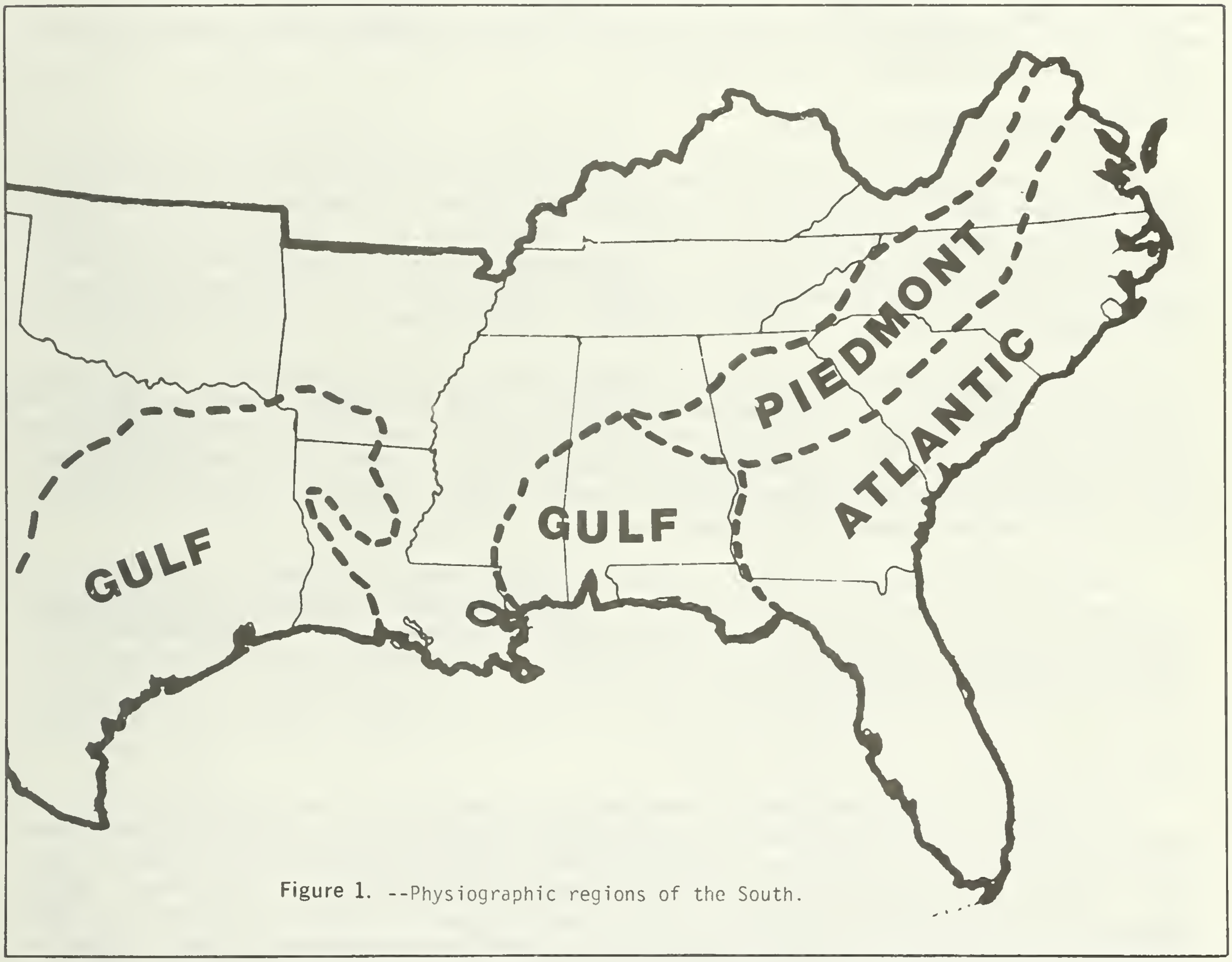


Figure 1. --Physiographic regions of the South.

B. Rainfall:

Evapotranspiration in the West Gulf area sometimes exceeds precipitation during the summer months, causing extreme competition for soil moisture between herbaceous plants and pine plantations. Research has shown, recently, that excess evapotranspiration and limited soil moisture can cause poor survival and tree growth in new pine stands unless herbicides are used. Shoulders and Haywood and Tiarks recommend weed control and fertilization at planting for early growth response of slash pine on poorly drained to moderately well drained upland soils. They also compared fertilized, bedded plots with weed control to unbedded, fertilized and weed-controlled plots and found no significant difference in 3-year tree growth on these soils.

Rainfall on the Atlantic Coastal Plain is rather evenly distributed throughout the seasons. This rainfall pattern allows adequate moisture for the planted pines and competing vegetation. Pritchett and Smith determined that bedding on a soil with standing water during the growing season could induce a growth response in pine seedlings. The bedding improves soil aeration, concentrates soil organic matter into planting ridges (making nutrients more available) and raises the seedlings' root system above standing water.

C. Soil texture and nutrients

Fisher and Garbett concluded that stands on fine-textured soils of savannah sites respond well to addition of P, while most stands on course-textured savanna soils respond only to additions of N and P. They also found that stands on coarse-textured upland soils show little or no response to N and P alone and only a weak response to N and P in combination. However, some stands on fine-textured upland soils respond to P alone, the best response is to N alone or N and P in combinations.

In the Upper Coastal Plain and Piedmont soils, N is the nutrient most often deficient. Sometimes, a combination of N and P might be needed. With an application of urea in early spring, N quickly moves into the soil for uptake by the tree roots. Avoid applying urea: (1) on soils with a pH of 5.5 or higher, (2) immediately before or after prescribed fires and (3) on warm, windy, dry days because nitrogen will be lost under those conditions.

Research has shown that pines thrive in soils with a pH range of 5.0-5.5. Ash from fire raises the surface soil pH values, and the greatest volatilization of ammonia occurs in soils with a high pH value--and especially during warm, dry and windy periods. The best use of N probably occurs when it is applied to moist soils shortly before a light rain.

Fertilizer usage in the United States

The major fertilizers used in the United States are: Urea in the Pacific Northwest; diammonum phosphate, urea and ammonium nitrate in the Piedmont and Upper Coastal Plain; and concentrated superphosphate in the Atlantic Coastal Plain. In 1979, close to 1 million acres of forest land in the South were fertilized. This acreage is increasing at an annual rate of 6.5 percent. The majority of fertilizer is applied at or near planting time, and the rest to established stands. Total acreage fertilized in the far West was approximately 1.5 million acres in 1979, with an annual increase of less than 6 per cent (Ballard).

The choice of fertilizer carriers depends upon the cost and availability of the product (table 1), application cost, and the responsiveness of the target species to the type of fertilizer.

Table 1. Some examples of carriers and relative cost of fertilization materials produced by the Tennessee Valley Authority, fob railhead.

Product	Percentage		1982 cost/ton (estimated $)
	N	P_2O_5	
Ammonium nitrate	33	0	192.00
Concentrated superphosphate	0	45	228.00
Diammonium phosphate	18	46	161.50
Urea ammonium polyphosphate	35	17	180.00
Urea ammonium phosphate	28	28	175.00
Ammonium polyphosphate	11	55	215.00
Sulfurcoated urea	36	0	340.00
Urea	46	0	175.00
Ground rock phosphate	0	46	50.00

Determination of Nutrient Requirements

Before applying a fertilizer, chemical tests of soil and/or foliage samples should be made to determine if in fact a particular nutrient is deficient. This step will help prevent needless expense of applying fertilizer to sites where it is unwarranted or ineffective.

P is the only nutrient for which a critical level has been determined for both foliage and soil tests. Even so, this value may vary with soil drainage properties, textures and the organic matter content of soils. The critical P value for needles analysis depends less on other variables than soil values. The unpredictable nature of tree response in relation to chemical levels in samples leaves researchers with many unanswered questions and unexplained answers. To make matters even more complicated, foliar and soil test values for N, K, Ca and Mg are derived from a limited number of field trials, or the results are borrowed from other pine species and minor adjustments made (Ballard).

Listed below are the approximate levels (or what are considered as levels) of N, P, and K, below which slash and loblolly pine would be expected to respond to fertilization (Pritchett and Gooding); (Wells).

	Soil		Foliar	
Element	NH_4OAC	$HCl+H_2SO_4$	Slash	Loblolly
	ppm		percent	
N	-	-	0.80-1.0	1.0 -1.2
P	1.5-2	4-6	0.08-0.09	0.09-0.10
K	10	10	0.25-0.30	0.25-0.30

The test for nutrients in soils or foliar samples can be administered at most agricultural colleges. The cost ranges from $0-5 per sample. Analysis done at most land-grant colleges may not give values in the range required for pine response to P because the laboratories' services primarily meet the needs of agricultural crops.

Foliar analysis has been more reliable than soil analysis in predicting the response of pines to P (Pritchett; Wells and Crutchfield). However, results with other nutrients as indicated above have been less satisfactory. The use of foliar analysis to indicate possible deficiencies depends on one's ability to get samples from healthy, rapidly growing trees. Trees under stress from disease, injury or deficiency in moisture or other nutrients may yield analysis values higher than would healthy trees. Sampling therefore depends on the judgement of the individual collecting the foliage.

The following are a few guidelines for collecting foliage material:

A. Trees 25 to 30 feet tall can be sampled with a long-handled pole clipper, while larger trees are best sampled using a gun. A fully choked shotgun with #4 shot is a good choice.

B. Take separate samples in areas of significant difference in soil type and stand growth.

C. The foliage collected should comprise a composite sample from dominant or codominant trees randomly selected from the area.

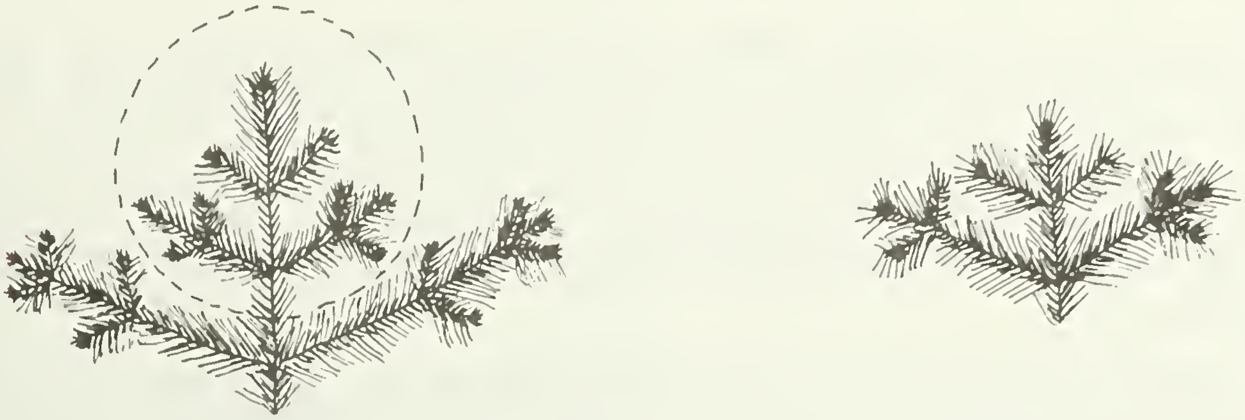
D. Adhere closely to the designated sampling method. See figure 2. A good sampling procedure would include these principles:

--Collect the sample between late August to January.

--Select sample of a primary lateral branch in the upper 1/3 of the crown (essentially free from light competition) on the south side.

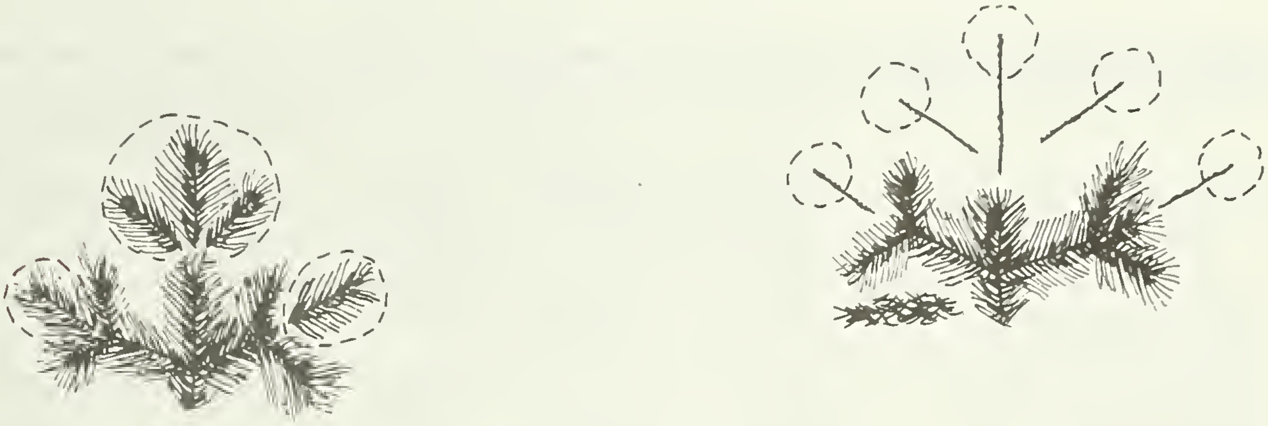
--Needles should be in their last flush of growth on the primary lateral. They should be representative of the crown and largely free of disease and insect damage.

--Avoid sampling during extreme weather conditions atypical of the season.



1. Location from which sample branch should be clipped

2. Branch after removal



3. Separation of current year's growth

4. Removal of needles which constitute the sample to be sent to the laboratory

Figure 2.---Procedure in foliar sampling. The leaves or needles have been chosen as the part to be sampled or analyzed because - aside from the fruit and seeds - they usually contain more of the nutrient elements than any other vegetative part, such as bark, wood or twigs. This figure is based on figure 7, in How to Fertilize Trees and Measure Response, by Stanley P. Gessel, Kenneth J. Turnbull, and F. Todd Tremblay; National Plant Food Institute, Washington, D.C. 1960.

Economics of Forest Fertilization

Forest fertilization considerations mentioned earlier have dealt primarily with the biological aspects. Research shows that significant growth responses are possible over a broad range of soils, physiography, and stand conditions. In light of the projected shortages of softwood fiber, fertilization offers foresters an exciting new production tool that will increase the available supplies of softwood fiber. However, foresters or private landowners would not be expected to use fertilization, or any other tool, in every stand. Rather, the use of fertilization should be targeted to those stands and sites expected to produce additional wood at a lower cost compared to any other production tool.

As a business investment, there is nothing unique or mysterious about forest fertilization. This practice involves an outlay of capital today with the potential of generating a return over and above costs at some point in the future. However, before any decision can be made about the economic or financial merits of fertilization, one must have reliable information on the physical response of the forest stand to a particular fertilizer treatment. Through research, fertilizer response data are rapidly becoming available to help predict relative growth responses.

Table 2, as reported by Bengtson provides some specific examples and perspective on the variability, magnitude, and value following fertilization of slash pine. Loblolly behaves in a similar way. The data in table 2 indicate that fertilization on certain soil types in the South affords some very attractive investment opportunities.

Table 2. Economics of fertilizing young and established stands of slash pine. Values are per acre. (Adapted from Pritchett and Gooding 1975.)

Site type and drainage	Site quality[1] range	Fertilizer		Expected yields		Rate of return[5]
		Materials[2] and amount	Cost[3]	Unfertilized[4]	Fertilized	
	Feet	*Pounds*	*Dollars*	*Cords*	*Cords*	*Percent*
	Fertilized at planting time and harvested at age 20					
Bays and wet savannas, very poorly to poorly drained	40-60	400 GRP + 100 urea	28.50	16	26-52	17-25
Flatwoods, poorly to somewhat poorly drained	45-65	400 GRP + 100 urea	28.50	22	28-32	14-17
Sands to loamy sand clay hills, moderately well to well drained	50-80	300DAP	30.00	33	37-39	11-14
	Fertilized at age 15 and harvested at age 25					
Bays and wet savannas, very poor to poorly drained	40-60	400GRP + 100 urea	28.50	21	26-34	23-35
Flatwoods, poorly to somewhat poorly drained	45-65	400 20-20-0	31.50	27	30-32	16-22
Sands to loamy sand clay hills, moderately well to well drained	50-80	500 20-20-0	39.00	41	43-45	9-16

---

[1] *Site quality = average height of dominant and codominant trees in unfertilized stands at age 25.*

[2] *GRP = ground rock phosphate, DAP = diammonium phosphate, 20-20-0 = mixed NP fertilizer.*

[3] *GRP at \$40 per ton, urea at \$225, DAP at \$165, 20-20-0 at \$120; application at \$0.0175 per pound; hauling cost \$1.50 per ton; management \$0.05 per acre (estimated costs Feb. 1974).*

[4] *Derived from Barnes, R. L. 1955. Univ. Fla. School of Forestry, Res. Rep. 3. Planting density 700 stems per acre.*

[5] *Rate of return:* $i = 100 (\sqrt[n]{\Delta Y/FC} - 1)$, *where:* n = *number of years investment carried.*

Δ Y = *value of increased stumpage (based on current stumpage price of \$25 per cord with annual increases in value of 8 percent, or \$45 per cord after 10 years and \$65 per cord after 20 years).*

FC = *fertilization costs.*

Research scientists have made progress in sorting out the biological and economic values of fertilization for timber production, and have presented guidelines of some value. In response, we as managers must learn the art of implementing research guides across a broad base. How well we implement these guides along with common sense, could make the difference between profit or bankruptcy in the future.

Literature Cited

Ballard, R. Fertilizers for use in forestry. (In forest soils short course.) Raleigh, N.C. State Forest Fertilization Cooperative, School of Forest Resources, N. C. State University; 1979: p 81-94.

Ballard, R.; and Pritchett, W. L. Soil testing as a guide to phosphorus fertilization of young pine plantations in the coastal plain. Bull. 778, Gainesville, FL: Florida Agricultural Experiment Station, Institute of Food Agricultural Science, University of Florida, 1975:22 p.

Bengton, George W. Forest fertilization in the United States: Progress and outlook. Journal of Forestry: 77(4):222-229; 1979.

Fisher, R. F.; Garbett W. S. Response of semimature slash and loblolly pine plantations to fertilization with nitrogen and phosphorus. Soil Science Society of America. Journal, 44(4):850-854; 1980.

Haywood, J. D. Combinations of foliar and soil applied herbicides for controlling hardwood brush. Research Note SO-247. New Orleans, LA: U. S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1979. 3 p.

Haywood, J. D.; Tiarks, A. E. Weed control and fertilization affect young pine growth, In Proc. Southern Weed Science Society, 1981. p 145-151.

Pritchett, W. L. Progress in the development of techniques and standard for soil and foliar diagnosis of phosphorus deficiency in slash pine. In Forest Fertilization Theory and Practice. Muscle Shoals, Al.: Tennessee Valley Authority; 1968. p 81-87.

Pritchett, W. L. and Gooding, J. W. Fertilizer recommendations for pines in the Southern Coastal Plain of the United States. Bull.: 774. Gainesville, FL: Agricultural Experiment Station. 1975. 23 p.

Pritchett, W. L., Smith, W. H. Management of wet savannah forest soils for pine production. Bull: 752. Gainesville, FL: Agricultural Experiment Station, 474: 22 p.

Shoulders, Eugene. Site preparation with fertilizers and other ameliorative measures. In: Proc. Site Preparation Workshop West, Atlanta, GA: U. S. Department of Agriculture, Forest Service, Southeastern Area; 1977. p. 18-26.

Shoulders E.; McKee, W. H. Pine nutrition in the west Gulf Coastal Plain: A status report. Gen. Tech. Rep. SO-2. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1973. 26 p.

Wells, C. G. Foliage sampling guides for loblolly pine. Research Note SE-113. Asheville, N.C.: U. S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1969. 4 p.

Wells, C. G.; Crutchfield, D. M. Foliar analysis for predicting loblolly pine response to phosphorus fertilization on wet sites. Research Note SE-128. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, 1969. 4 p.

Wells, C. G.; Crutchfield, D. M.; Berenyi, N.M.; Davey, C. B. Soils and foliar guidelines for phosphorus fertilization of loblolly pine. Research Paper SE-110. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1973. 15 p.

Williston, H. L.; LaFayette, Russell. Species suitability and pH of soils in southern forests. Unnumbered forest management Bull. Atlanta, GA: U. S. Department of Agriculture, Forest Service, Southeastern Area; 1978. 4 p.